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From a breeze to the four winds: A panel analysis of the international diffusion of renewable energy incentive policies (2005–2015)

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ABSTRACT

How do renewable energy policies (REPs) diffuse internationally? Are there differences between developed and developing countries? Which actors are diffusing these REPs? Also, what predominates when considering REP diffusion, national or international factors? The goal of this paper is to analyze the main vectors and actors that influence renewable energy policy adoption and identify differences between developed and developing countries. We access those questions by a mixed method analysis: quali and quantitatively. First, we discuss qualitatively the main external, intermediate and internal actors behind international wind energy policies diffusion. Then, we estimate a Poisson regression model using data for 194 countries, 102 of which are developing countries, from 2005 to 2015 testing the role of policy diffusion mechanisms on renewable energy policy diffusion. Among the main results, we found strong evidence of socialization and learning on international policy diffusion to developing countries, while domestic factors play a major role, especially with regard to market liberalization in developed countries. We also show some of the key actors related to REPs and we note that the causal mechanisms that lead to the adoption of REPs may differ among countries according to their level of economic development.

1. Introduction

How do renewable energy policies (REPs) diffuse internationally? Are there differences between developed and developing countries? Which actors are diffusing these REPs? Also, what predominates when considering REP diffusion, national or international factors? This paper tries to answer these questions.

In recent years the international community has become increasingly concerned with the generation of greenhouse gases (GHGs) and their environmental impacts. Among the activities responsible for GHG emissions, energy generation and use accounted for 34% of global emissions in 2013 and the largest volume of emissions was directly related to electricity (IPCC, 2014). Furthermore, most of the energy produced in the world came from non-renewable resources: 81.2% from fossil sources and 4.7% from nuclear sources. Only a small part came from renewable sources[2]: 10.2% from biofuels, 2.4% from hydroelectric plants, and 1.4% from wind, solar and other renewables (IEA, 2016).

We suggest that the promotion of renewable sources had important effects on domestic energy policies. In fact, given the challenge of coordinating countries to implement an international climate change regime, such as the failing Kyoto Protocol, there is a growing effort to boost the implementation of renewable technologies domestically (Jordan and Huitema, 2014). Nevertheless, energy security and economic development still play relevant roles on this process (Mitchell et al., 2011). Since the first oil price shock, which generated a worldwide recession, energy became a fundamental part of strategic economic growth. Therefore, considering the intrinsic limitation of non-renewable sources, their price volatility and the negative externalities for the environment from their exploration, it does not come as a surprise that countries are increasingly promoting renewable energy.

From 2005 to 2014, the number of countries that had adopted at least one policy to encourage renewable energy rose from 43 to 138 (REN21, 2014). The literature has already begun to answer the drivers behind this process, separating them into two categories: international

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[2] According to the International Renewable Energy Agency (IRENA, 2009), renewable energy is derived from natural sources that are replenished at a higher rate than they are consumed (e.g. solar, wind, geothermal, hydroelectric).

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and national factors. (e.g. Kern et al., 2005; Holzinger et al., 2008; Jenner et al., 2012; Nicolli and Vona, 2012; Biesenbender and Tosun, 2014; Fankhauser et al., 2014; Massey et al., 2014; Stadelmann and Castro, 2014). Although simplistic, this distinction can provide important insights. On the one hand, domestic variables explain differences among countries subject to the same international rules and with access to similar technical and scientific information. On the other hand, even in face of domestic idiosyncrasies, it is reasonable to expect that the adoption of REPs will be related to international linkages, either through intergovernmental institutions, civil society or private groups – setting up an international diffusion policy process scenario.[3]

The literature seems to agree that international diffusion mechanisms do influence the adoption of REPs in general. Domestic factors, such as the abovementioned issue of energy security, may play a greater role (Stadelmann and Castro, 2014). Nevertheless, there are still some pieces missing in this puzzle. First, despite important contributions, the literature focuses either on developed or on developing countries, using incomparable parameters. We are not aware of any studies that have tried to address both groups of countries simultaneously. Second, there is an important gap in this research agenda, considering that only two papers (Fankhauser et al., 2014; Stadelmann and Castro, 2014) address developing countries' performance. In 2010, about 70% of carbon emissions produced by the energy sector in the world were from this group of countries (IPCC, 2014). Third, who are the actors behind this process? Although the literature assesses the process, it minimizes the role played by the actors that move the gears of diffusion (Graham et al., 2013). Last, but not least, the diffusion of REPs in some developing countries, as in the case of Brazil, may be connected to two important processes that have not been identified by the existing literature, as far as we are concerned. The first is the pervasiveness of digital technologies and the second is the 2007/2008 crisis that shrunk developed countries' markets.

Our main goal is to analyze and identify the vectors and actors of the domestic and international spheres that influence countries' decision to adopt REPs, and whether this differs between developed and developing countries. In order to achieve this, the next section presents REPs and a literature review on the theory of international policy diffusion. At this point, we also explore the role of the actors (external, intermediate and internal) involved on diffusion of policies focusing on the wind sector. Section 3 discusses methodology and data; we analyze the adoption of REPs, measured by the number of policies adopted by year. We estimate Poisson models for a panel covering 194 countries from 2005 to 2015. Here, we explore the international diffusion mechanisms that have been previously identified by the literature – learning, socialization (or emulation), competition and coercion (Simmons et al., 2008; Graham et al., 2013); which are also compared to domestic factors (classified into socio-political-economic factors, energy security factors and interest groups). Section 4 presents the results and discussion and tries to make sense of how REPs diffuse internationally and Section 5 suggests some conclusions, policy implications, and a future research agenda.

2. International diffusion of REPs: mechanisms and actors

Policies to support renewable energy can be divided into three categories: technological (including R&D), industrial (protection to domestic industry) or market regulation policies (Dutra, 2007; Podcameni, 2014). Market regulation policies, as outlined in Table 1,[4] can be based on quantity (quotas, such as renewable portfolio standards, RPS), price (establishing differentiated tariffs, such as feed in tariffs – FITs) or auctions.[5]

One of the first regulatory frameworks to encourage the renewable sector was launched during the 1970s, in the United States (USA): the *Public Utility Regulatory Policies Act* – PURPA (1978). During the 1980s, this type of mechanism spread, initially to Denmark and then to other countries. Throughout the 1990s, two types of market policies predominated: FITs and quotas. Auctions became more popular in the 2000s, especially among developing countries, after its initial failure in the United Kingdom (UK) in the 1990s (Del Río and Linares, 2014).

By 2003, only 18 countries, all European, had implemented FITs. By 2015, it became one of the most popular REPs in the world, as it ensures long-term financial stability (see Fig. 1).

The growing interest in auctions is assigned to the possibility of efficiently deploy renewable energy, with lower energy prices, despite high transaction costs (IRENA and CEM, 2015). Both auctions and quotas are spreading and, in many cases; they are being applied in a complementary way. Notably, the option for auctions grew at a faster pace between 2010 and 2015 in developing countries.

Fig. 2 shows the evolution of the number of policies from 2005 to 2015 by income group and indicates a significant increase in the average of the number of REPs, considering significant differences among groups. In developed countries, the average number of policies almost doubled in the period, while in developing countries the number quadrupled.

Is this a diffusion policy process? A standard policy diffusion definition is the adoption of policies by a political unity being influenced by other actors (Graham et al., 2013). There are many terms to illustrate this interdependence, which are generally put into four groups: learning, socialization (or emulation), competition and coercion (Simmons et al., 2008).

Learning is characterized by policy success in other units, assuming that countries learn from each other. Governments rely on the recommendations of other countries or international organizations (IOs) that monitor the performance of certain measures elsewhere (Berry and Berry, 2007). In contrast to learning, socialization (emulation) is not related to the consequences of a given policy, but to symbolic characteristics, socially constructed from the performance of an external actor (Maggetti and Gilardi, 2016). Competition portrays a reaction to the actions of other units. For example: those competing for resources and prestige and seeking advantages over each other (in relative and absolute terms). Finally, coercion can be identified when powerful actors try to enforce their preferential political solutions on others by imposing punishments, sanctions or conditions (Busch and Jörgens, 2005).

The literature on REPs adoption is presented in Table 2.

Stadelmann and Castro (2014) suggest that domestic variables have a greater influence on the policy adoption process, when focusing countries from the global South. However, when the focus is on the diffusion of adaptation policies across Europe, Massey et al. (2014) point out that external drivers are more prominent. Biesenbender and Tosun (2014) suggest that the adoption of climate policies in OECD countries is more influenced by learning through IOs, while the process of policy change is dominated by national interest groups and may be influenced by greater representation of a green party.

Overall, existing literature assesses how REPs are being adopted. However, as far as we are concerned, two relevant aspects are missing. First, a research strategy that compares both developing and developed

[3] Due to their position in the international system, it might seem more likely to expect developed countries adopting similar policies to their peers. Nevertheless, developing and lower income countries are more susceptible to the adverse effects of external situations, such as international crisis. Consequently, they might try to catch up on international trends in order not to be left behind.

[4] We considered REN21's classification, since it is the largest database available on the subject.

[5] Although auctions are not policies per se, they are mechanisms that encourage competitive activity and therefore can be identified as such (Maurer and Barroso, 2011).

Table 1
Ten types of market policies according to REN21 (2005).
Source: based on Dutra (2007), Nicolli and Vona (2012) and REN21 (2014).

Instrument	Definition
Feed-in tariffs (FITs)	A policy that sets a guaranteed price for a fixed period in which producers can sell renewable energy to the grid. Some policies offer a fixed rate, while others provide fixed premiums or tariffs linked to the generation costs. Feed-in rates are expressed in national currency per kW h or MW h.
Quotas or obligations	It imposes energy suppliers the obligation to have part of their power supply from renewable sources. Quotas are not necessarily covered by tradable certificates. Examples are the renewable portfolio standards (RPS) in the United States and the renewable portfolio obligations (RPO) in the United Kingdom.
Renewable energy certificates	Renewable Energy Certificates (RECs) consist of negotiable financial assets issued by the regulatory body, which certifies the production of renewable energy. Alongside the introduction of a system of certificates, a separate market is generally established where producers can market certificates. The price of the certificate is determined by the market. RECs are also known as green labels or renewable certificates. They allow the buyer to pay for renewable generation without the need for physical or contractual delivery of electricity generated from qualifying energy sources.
Tendering, auctions or competitive bidding	Either price or quantity are determined before the decision to implement the projects.
Net metering	Incentives to the installation of meters that allow a bidirectional flow of electric power between the distribution network and the customers with its own generation. Customers pay only for the net electricity used.
Capital subsidies	Subsidized capital or subsidized interest rates, accelerated depreciation and other measures to reduce the cost of capital in the adoption of renewable sources.
Fiscal credit to production or financing	Tax incentives to production, such as credits or investment tax subsidies, as well as property tax exemptions.
Fiscal reductions to consumption	It includes all consumer tax incentives, such as a reduction in energy sales taxes or excise taxes or value added tax (VAT).
Payments to energy production	Public payment per unit of renewable energy produced.
Public investment or public finance	Public investment, special lines of public financing and/or risk guarantees. They may also take the form of financial arrangements involving third parties, where governments assume some of the risk or provide a low interest rate on loans.

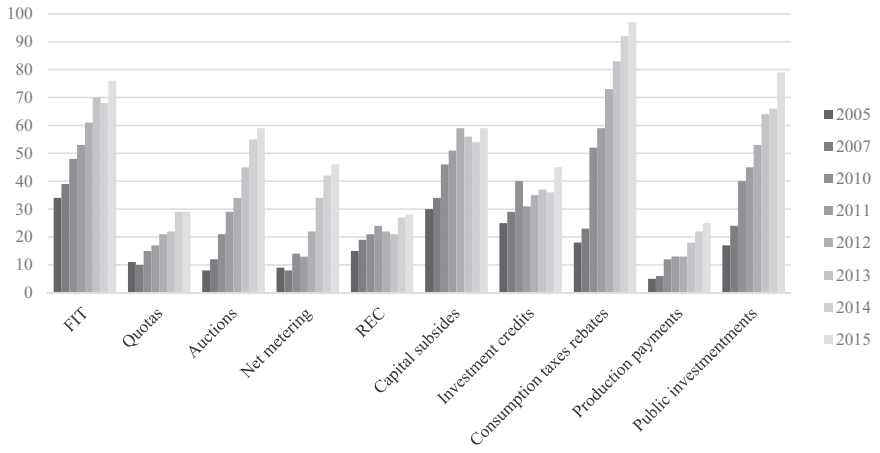

Fig. 1. Number of countries with REPs by type, between 2005 and 2015.
Source: based on annual reports of REN21 (2005, 2007, 2010, 2011, 2012, 2013, 2014, 2015).

Fig. 2. Average number of policies by group of income.
Source: based on REN21 (2005, 2007, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016). For missing data we used linear interpolation. We follow World Bank classification on gross national per capita income available at: https://blogs.worldbank.org/opendata/new-country-classifications, accessed April 19th, 2017.

countries. Second, an analysis that highlights the actors behind this process. After all, who is diffusing REPs?

By pointing out the main limitations of the policy diffusion analytical framework, Graham et al. (2013) suggest that focusing on the process minimizes the role played by actors. Here, we aim to present some of the main actors related to the global diffusion of REPs, emphasizing the wind sector, since it is a relatively more developed sector (in terms of installed capacity) compared to other renewable sources (excluding hydropower).

Global environmental governance can be characterized by: a) increased participation of non-state actors (epistemic communities, environmentalists, multinational corporations, intergovernmental organizations); b) new forms of cooperation, beyond international agreements (partnerships and sharing networks) and c) policy-making by vertical (multilevel governance) and horizontal means (multi-polar governance) (Biermann, 2006).

Considering this, we present: i) external actors (pioneer countries on REPs adoption and private groups that operate in the wind sector and incentive REPs adoption mainly through competition and learning); ii) intermediate actors (IOs, for example, facilitating learning and socialization), and iii) actors at the domestic level, such as environmental organizations, as well as organized interest groups.

Table 2
Literature review.

Authors	Independent variables		Analysis technique	Sample	Period	Main results
	Domestic	Internationals				
Kern et al. (2005)	1. national capacity; 2. income; 3. environmental problems; 4. consolidated policy model	5. International conferences; 6. adoption by pioneer countries; 7. international organizations; 8. Transnational networks of civil society.	Cases studies	Developed countries		Institutional capacities of the country, dynamics of the international system and specific aspects of politics.
Holzinger et al. (2008)	1. income; 2. Green party (GP); 3. population density; 4. use energy; 5. CO2 emissions	6. IOs; 7. transnational communication (emulation, learning and epistemic communities); 8. regulatory competition (bilateral trade, economic opening); 9. cultural similarity	Multiple regression. Peer Approach.	24 industrialized countries	1970, 1980, 1990 e 2000	IOs; transnational communication and cultural similarity.
Nicolli and Vona (2012)	1. income; 2. inequality; 3. market structure; 4. energy prices; 5.corruption; 6.part. policy; 7. education; 8. political stability; 9. women in power	10. Kyoto ratification	Dynamic panel	OECD countries	1970–2005	Income; Inequality, Kyoto, and energy prices all have significant impacts.
Jenner et al. (2012)	1. Green Lobby; 2. brown lobby; 3. ment; 4. price of electricity; 5. air pollution; 6. unemployment; 7. PV; 8. solar potential	9. Neighbor adopted; 10. Member of the EU.	Logistic panel	27 European Union countries	1990–2010	Green lobby; Natural potential and unemployment increase the chances of adopting policies. Concentration in the electricity market decreases.
Biesenbender and Tosun (2014)	1. Political change; 2. political party; 3. income; 4. CO2 emissions	1. Learning: country party to the Air Pollution Convention (1979) or the NOx Emission Protocol (1988); 2. Emulation: neighboring country adopted; 3. emulation: EU country adopted; 4. EU coercion; 5. competition: 6. trade opening; 7. Competition: 8. FDI entry.	Cox Regressions	24 OECD countries	1976–2005	Competition and air pollution minimize the probability of adoption. Significant impact of learning on policy adoption.
Fankhauser et al. (2014)	1. Democracy; 2. electoral cycle; 3. executive strength and type of government; 4. existence of a general climate policy; 5. party; 6. economic cycle; 7. income	8. seat of COP; 9. pressure for adoption in even countries; 10. Kyoto Protocol.	Negative binominal panel with fixed effects	63 countries. Sub-samples apply.	1990–2012	External factors: the effect of group pressure and host a COP. Domestic: existence of a general climate policy; Strong executive power
Massey et al. (2014)	1. climate events; 2. public opinion; 3. recognition of the policy; 4. institutional capacity; 5. Financial resources and 6. Income	7. scientific research; 8. OIs; 9. EU; 10. international funds; 11. pressure from NGOs; 12. other countries	Survey online	29 European countries	2012–2014.	External factors: scientific research; Efforts of the EU and the OECD and UNFCCC. Among domestic ones, extreme weather events.
Stadelmann and Castro (2014)	1. Energy security; 2. air pollution; 3. natural dictation; 4. end; 5. education; 6. population; 7.democracy; 8.veto players; 9. environmental groups; 10.public opinion	11. Adoption by neighbors; 12. Adoption by peers of the same language; 13. adoption by peers with the same colonial history; 14. economic block or region; 15. colonizer adopted; 16. international funding; 17. Member EU	Cox Regressions	106 developing countries	1998–2009	Domestic factors: population and income. International factors: emulation of colonial peers and EU member.

In some policy diffusion studies, external actors are ignored (Graham et al., 2013). However, there are several examples of the role of external actors in the dissemination of policies (Elkins et al., 2006; Stadelmann and Castro, 2014). The first countries to adopt REPs were Denmark (FITs in 1981), Germany (FITs in 1989), the United States (quotas, during the 1990s) and the UK (auctions, in the 1990s) (Berger, 2010). Government incentives led these countries to expand consumer markets, which consolidated their position as pioneers in the global wind market. Over time, the wind sector expanded to countries in Africa, Eastern Europe, and Latin America, as well as China and India. As a result, the industry strengthened, despite attacks on the legal structure that was beginning to become more robust.

With the market consolidation, companies from these countries have become important conglomerates of the global economy. By 2014, the world's top ten wind turbine manufacturers accounted for approximately 70% of the market (REN21, 2015). This structure reveals one source of REP diffusion by competition. However, in this case, it is different from how it has been recorded by the environmental policy literature, in which countries loosen the legislation to attract foreign companies. Brazil, for example, decided to implement auctions in 2009 precisely to attract foreign capital (Maurer and Barroso, 2011; Melo, 2013). This is an example of a country adopting instruments in order to boost national wind generation.

Clapp and Meckling (2013) point to several ways in which multinationals can influence the adoption of environmental policies, from lobbying to influencing the drafting of laws. In general, private action in politics is carried out in overlapping and complex ways, through formal and informal interventions, and at global and local scales. These same authors note that the role played by certain private groups is usually linked to the performance of business councils. The influence of such actors on political decisions is also related to their performance and use of the technology in question. This topic is especially relevant to the wind sector, as it is shaped by few, large, global companies. Companies that own property rights of certain technologies, for example, can use them to encourage policies that increase their market position. This has been documented by Falkner (2003), when studying the role of private actors in environmental governance, and by Levy and Newell (2005), on climate change related policies. In addition, it is possible to identify indirect ways of influencing these groups on the formulation of environment-related policies, as through the language of official documents, for example, as suggested by Clapp (2005) and Cox (2012).

Regarding intermediate actors, classic examples focus on intergovernmental organizations (Graham et al., 2013), although this group also includes epistemic communities, public-private partnerships and advocacy networks. All of them can support the adoption of certain policies by disseminating information, through reports and studies, or by providing forums for negotiating and sharing experiences.

In this context, policies are disseminated through learning, to share the success of particular programs in pioneer countries; through socialization, by promoting a change in countries' self-perceptions; or even through coercion, as in the case of supranational entities such as the European Union (Kern et al., 2005). The main IOs in the field of renewable energy are the UN system, the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the World Bank Group and the European Union, the latter being relevant at the regional and global levels.

Other important intermediate actors are epistemic communities. The Intergovernmental Panel on Climate Change (IPCC) is the main body that brings together epistemic community leaders on climate change. It is recognizably the most influential epistemic community in transnational relations, as the process of environmental policymaking depends on accurate and reliable information (Williams, 2005; Downie, 2013). It was created under UNEP in 1988 and now has 195 countries, and scientists who contribute to the agency do so voluntarily (IPCC, 2014).

The organization has a secretariat in Geneva and works in coordination with member governments. With a mixed scientific and intergovernmental nature, when governments approve IPCC reports they recognize the authority of their scientific content. Its structure is based on three working groups: group one investigates atmospheric science issues, group two is focused on socioeconomic impacts and adaptation measures, and group three is focused on mitigation alternatives (IPCC, 2014). By 2016, five evaluation reports had been produced (1990, 1995, 2001, 2007 and 2014) containing technical-scientific assessments on climate change and with clear national policy guidelines for the development of the renewable energy sector in the countries.

The first report produced in 1990 had a significant impact on the international community. According to Johnson (2012), the fact that renowned scientists came to the public – claiming to be sure of the effects of human activities on climate change – was surprising. At the time, the opinion of working group three already pointed to possibilities and measures to be taken by policy makers, among them the commitment to increase energy efficiency and the use of clean and renewable energies (Johnson, 2012, p. 90). In addition to the evaluation reports, the agency also produces special reports focusing on particular aspects related to the many human activities with projections on climate change. One of these had a direct impact on the discussion on renewable energy. The 2011 report, Renewable Energy Sources and Climate Change Mitigation (IPCC, 2011), included clear guidelines for policy makers by type of technology, policy detailing, funding and implementation.

However, in spite of being a relevant and essential factor in disseminating elements that may encourage countries to adopt significant policies, IPCC's declared political perspective is neutral and non-prescriptive (IPCC, 2014). In addition, perceptions about their performance are contradictory. On the one hand, there is a cognitive pressure on decision-makers around the need to contribute to effective policy responses. Downie (2013) notes that the agency was responsible for persuading key political actors in international negotiations on human action on climate change. In that sense, IPCC promotes the diffusion of policies through socialization. On the other hand, Haas (2005) argues that the IPCC is designed to keep science on a tight collar and that scientists have been unable to exercise sufficient discretionary power to develop more effective policy suggestions.

Public-private partnerships for energy policy are also important intermediate actors. These partnerships establish networks that incorporate different social actors within governments, IOs, corporations, research institutes and civil society movements. Stripple and Stephan (2013) emphasize that these actors are not politically neutral, yet their role is minimized because it is not directly related to clear mechanisms of power. However, the ability to determine the criteria in which funding is distributed, for example, puts such networks in positions of power and influence over strategic decisions of many governments. While analyzing the effectiveness of partnerships of this nature in the sustainable energy sector, Szulecki et al. (2011) recorded activities related to knowledge dissemination, technology transfer, technical implementation, training and the development of planning skills. Thus, their performance pervades learning and also functions as an instrument of socialization and learning.

More than 350 partnerships were established at the 2002 World Summit on Sustainable Development, of which 46 (13%) focused primarily on energy issues (Zelli et al., 2013). Among these, we can highlight influential networks such as the Global Compact, Renewable Energy and Energy Efficiency Partnership (REEEP), the Renewable Energy Policy Network for the 21st Century (REN21), the World Energy Council (WEC), among others. In face of financing constraints for the operationalization of projects, one of UNEP's activities in the energy area is focused on the creation of public-private networks, such as REN21. This network, one of the most important in the field, leads countries towards green economy, using renewable energy and encouraging technical and political support. It is composed of over 60

Table 3
Mechanisms, hypotheses, variables and coding.

		Hypothesis	Variable label	Definition
Domestic factors	Political economic factors	*H1: countries with higher income levels are more likely to support the adoption of REPs*	Income	Per capita income
		H2: higher levels of democracy have positive effects on REPs adoption	Democ	The country's democracy score, according to Polity IV (from − 10 to 10)
		H3: countries with green party representatives are more likely to adopt REPs	Green_party	Presence of green party in the country (0 if no and 1 with there is, on that year)
		H4: higher levels of CO_2 have a positive effect on REPs adoption.	Carbon_emission	Level of carbon emissions in the power sector in percentage
	Energy security	*H5: countries with lower energy security are more prone to adoption of PERs.*	Eng_exporter	If the country is an energy exporter (0 if no and 1 with yes)
	Interest groups	*H6: higher brown lobby performance are less likely to adopt PERs.*	Fossil_lobby	Percentage share of the fossil sector in the energy matrix
			Electric_mkt_structure	Market Structure (it goes from 0 to 6. The higher the PMR, less liberalized is the power sector)
International diffusion mechanisms	Learning	*H7: member countries of business councils have a positive effect on the adoption of PERs*	Gwec_member	If the country is a member of the Global Wind Energy Council (GWEC) (0 if nonmember and 1 if member)
		H8: EU member states are more likely to adopt PERs.	EU_member	If the country is a member of the European Union (0 if nonmember and 1 if member)
	Socialization	*H9: countries with greater lobbying of the green lobby are more prone to adoption of PERs.*	Kyoto	If the country is a signatory to the Kyoto Protocol (0 if no and 1 if yes)
		H10: Countries with higher levels of international socialization are more likely to adopt PERs.	Greenpeace_member	If there is a Greenpeace representation at the country (0 if no and 1 if yes)
			Num_Pol_Neighbor	Average number of REPs of neighbor countries in the region in the previous year
			Internet	Percentage of internet users in relation to population
	Comp.	*H11: countries with greater economic integration are more prone to adopting PERs.*	Trade_open	Trade in relation to GDP (percentage)
			Crisis_2008	Variable referring to the 2008 Crisis (dummy variable scoring 1 at 2007 and 2008)
	Coert	*H12: Countries with more World Bank loans are more prone to adoption of PERs.*	Wbloans_gdp	Volume of World Bank loans, in relation to the country's GDP (percentage)

members that include representatives of national governments, international organizations, industry associations, science and academia, NGOs and individual members. In addition to major annual publications, the network also promotes, every two years, the International Renewable Energy Conference (IREC), an international conference that brings together leaders and actors from the private sector and civil society, to discuss and exchange experiences to accelerate the global scale of renewable energy (REN21, 2015).

The first International Renewable Energy Conference was held in Bonn, in 2004, with some 3600 participants and one of the main results was the creation of the global policy network itself: REN21. In 2010, the host city was New Delhi, where about 13,000 delegates from 70 countries met. The Final Declaration of the event reinforced the political momentum for the deployment of renewable energies throughout the world. Considering the climate debate in Cancun that same year, renewable technologies have been central to the development of low-carbon economies. Throughout the event, about 32 commitments were announced to promote these sources, most by national governments.

Finally, domestic groups shape the pattern of policy diffusion by creating favorable environments for adopting new policies or by vetoing initiatives by opposing them. An example of such reasoning is the case of Germany. According to the Falkner (2013), since the German Green Party was created the country gained international leadership on environmental issues, particularly after the party was able to form a coalition government with the Social Democrats in 1998.

Parsimonious analyses should consider a broad range of internal actors with potential policy relevance: elected politicians, bureaucrats, political parties, interest groups, civil society movements, and domestic advocacy networks. Here, we present some internal actors groups with a transnational role, focusing on the movements of civil society and interest groups related to the wind energy sector. They are assigned as internal, because, despite their strong cross-border expression, they have a direct influence on the political decision-makers at the national level.

In attempting to answer why countries began to engage in an effort to promote a transition to renewable energy at the very beginning of the twenty-first century, Simon (2007) identifies multiple causal factors. Among them, the author highlights the emergence of an environmentally sensitized society, supported by the strengthening of civil society movements. Thus, a key group for understanding the diffusion of norms and values related to the environmental issues and the effects of the climate change is that of civil society organizations.

Networks of activists intend to go beyond policy changes by modifying the terms and nature of the debates through socialization, by influencing agenda setting to change countries' behavior (Keck and Sikkink, 1998). In the first decade of the 21st century, the number of organizations grew exponentially due to – among other reasons – greater democratization and access to media and information (Downie, 2013).

From a global point of view, three NGOs have been directly involved in the promotion of renewable energies: the World Wide Fund for Nature International (WWF), Greenpeace International and Eurosolar – determinant to the adoption of FITs in Germany (IRENA-GWEC, 2013). Some research institutes are also important, conducting research in public policy and providing advice on the implementation and evaluation of environmental policies: the World Resources Institute (WRI), the International Institute for Environment and Development (IIED), the Center for Science and the Environment (CSE) and the Institute for European Environmental Policy (IEEP).

Last, but not least, classic models of international environmental political economy highlight the role of specific sectoral lobbying (Lopez and Mitra, 2000; Fredriksson et al., 2004). In the case of energy, incumbent groups, called the brown lobby (representatives of the fossil fuel industry or regular power utility companies), support less rigorous REPs. Whereas environmental groups and companies operating in the new technologies sector, the green lobby, seek to boost REPs (UNEP, 2011; Obama, 2017).

One way of investigating the action of private pressure groups is through the activities of business councils. These groups support large companies by sharing information and positioning coordination. Thus, they establish channels of communication with companies, representing them in government agencies and monitoring negotiation processes, in order to ensure their interests. In the case of wind power, business councils work as a green lobby. Globally, the most important of them are the Global Wind Energy Council (GWEC) and Wind Europe (former the European Wind Energy Association – EWEA).

3. Methodology and data

The variables of interest and the hypotheses are presented in Table 3, along with the coding of the variables. At this point, we present the two axes of independent variables that supported the research: domestic and international variables. Similar to Stadelmann and Castro's (2014) research strategy, we classify domestic variables into three categories: socio-political-economic factors; energy security factors and interest groups. International variables were grouped according to the related diffusion mechanism: learning, coercion, competition or socialization.

3.1. Domestic variables: socio-political-economic factors, energy security and interest groups

The first variable of interest is income. As seen in Table 2, it is present in all studies on REPs diffusion. Two causal mechanisms explain their relation. The first is the higher the income, the greater the demand for energy. The second argument is based on the environmental Kuznets curve (Stern, 2004). In this case, the richer the country, the more conditions it has to pay for renewable technologies. This is because countries with higher *per capita* income will have greater ability to invest in technologies that are initially offered at prohibitive costs. We used the GDP *per capita,* measured in constant 2005 US dollars (available at the World Bank's website[6]) to classify the countries according to level of income.[7]

The literature also considers political and institutional aspects on REP adoption (Fankhauser et al., 2014; Stadelmann and Castro, 2014). The rationale is that democratic rulers generally follow the preferences of voters, who are ultimately benefited by environmental policies. It is necessary to consider that, precisely in democracies, the performance of interest groups contrary to the adoption of policies is also important, and the literature attempts to address this phenomenon by measuring the brown lobby's performance. To measure the level of democracy, we used the polity2 index of the Polity IV project.[8] The index has an annual score ranging from − 10 to + 10, in which the higher the score, the more democratic the regime.

Half of the studies presented examine the impact of a green party on the adoption of policies, according to the reasoning presented before. Similar to Stadelmann and Castro (2014), we created a *dummy* variable where there were political representatives elected by the party in the country. Data was coded from Global Greens – an international network of green parties.[9]

[6] Available at: http://databank.worldbank.org/data/home.aspx, accessed on 31 October 2016.

[7] Country classification group of income follow World Bank classification according to gross national per capita income: high income are countries with income correspondent to US$ 12,616 or more, and middle income countries those with U$ 1036 to US$ 12,615. Low income countries with income up to US $ 1035.

[8] Available at: http://www.systemicpeace.org/inscrdata.html, accessed on November 3rd, 2016.

[9] Available at: https://www.globalgreens.org/officeholders, accessed on November 3rd, 2016.

One increasingly accepted hypothesis is that CO_2 emissions are the main driver behind global warming (IPCC, 2014), which suggest that higher levels of CO_2 emissions are related to the emergence of national and international demands for environmental protection (Holzinger et al., 2008; Biesenbender and Tosun, 2014). To capture this effect, we used data on the CO_2 emissions from electricity and heating production (as a percentage of total fuel combustion) available in the World Bank database.

Concerns around energy security and volatility of energy prices are the most straightforward explanations for countries to start to encourage renewable energy (Jenner et al., 2012; Nicolli and Vona, 2012; Stadelmann and Castro, 2014). From this perspective, it is understood that countries' energy choices are influenced by oil prices and the vulnerability of energy supply. In addition to influencing political actors, oil price fluctuations also serve as a market benchmark for private investment decisions in renewable sources. Due to a substitution effect, rising oil prices are expected to reduce the demand for this resource. In spite of this, Dechezleprêtre et al. (2012) and Nicolli and Vona (2012) warn that this assumption is only valid up to 1990. From this year on, the authors suggest that there was a decoupling between oil prices and technology diffusion. Moreover, oil prices do not vary among countries, so that its influence cannot be tested in fixed-effect models (Stadelmann and Castro, 2014). Therefore, we decided to insert the hypothesis of energy security with a dummy variable for the cases when the country was a net energy exporter, based on World Bank's database mentioned above. Therefore, we expected this variable to have a negative effect on REP adoption.

From an empirical point of view, the adoption of REPs affects two interest groups: those that benefit from the measures (green lobby) and those that lose (brown lobby). Nicolli and Vona (2012) consider that the recent liberalization of energy markets has favored the adoption of REPs. The authors conclude that the more liberalized the electricity sector, the less the brown lobby will be able to influence it. In fact, several authors have measured the action of interest groups using barriers to entry data for the energy sector and analyzing the energy market structure index provided by the OECD[10] (Jenner et al., 2012; Nicolli and Vona, 2012). The rank goes from 0 to 6, where 6 is the maximum anti-competitive regulation. Therefore, the higher the score, the stronger the brown lobby and, thus, the lower the expected effect on REP adoption. This index is only available for OECD countries, so it was only tested on the sample of developed countries. Another variable used to capture the strength of the brown lobby was the percentage of total electricity produced from oil, gas or coal, also available from the World Bank's database.

3.2. International mechanisms for policy diffusion: learning, socialization, competition and coercion

Learning is one of the main mechanisms of policy diffusion between countries, and is related to the success of the policy elsewhere; in this case, the publication of information and technical content support political decisions. Thus, IOs play a key role through the sharing of experiences and cases of success. As most countries are members of the UN system's programs, it is difficult to include such a variable in the analysis. Therefore, we considered the role of the EU (using a dummy variable), similarly to the literature presented in Table 2. We also included the role of business councils, although they can also represent the green lobby. We used a dummy variable when the country's wind industry association was a member of the Global Wind Energy Council (GWEC).[11]

Socialization (or emulation) is related to the symbolic characteristics – socially constructed by multiple actors and by intersubjective aspects of human interaction and present in culture or intangible institutions. Civil society movements, especially environmental groups, influence public awareness through changes in beliefs and values; encompassing the green lobby. To investigate the effect of the pressure of environmental activism, we followed Stadelmann and Castro's (2014) strategy to create a dummy variable for countries with Greenpeace representation. In order to capture the effect of the climate change regime on changing values in international society, we follow authors who use a dummy for the ratification of the Kyoto Protocol (Fankhauser et al., 2014). Still on the socialization group of mechanisms, we tried to measure the importance of neighboring countries that may have adopted similar policies, a variable that was useful in other studies. We employed the average number of policies adopted by countries in the same region in the previous year. Finally, according to Cox (2012), the way in which environmental issues are communicated matters, as it directly affects the way of thinking about and formulating policies. The Internet has profoundly altered communication and public opinion (Dahlgren, 2005; Dietz et al., 2008). Therefore, we can assume that internet access had a significant influence on the adoption of REPs. We used the percentage of the population with Internet access, available in the World Bank database.

Competition takes place through the adoption of policies by countries disputing for specific markets. Regulatory competition is an important factor that promotes the dissemination of policies (Holzinger et al., 2008; Simmons et al., 2008). Trade liberalization facilitates the movement and exchange of goods and services, promoting competitive pressure on country regulation. This mechanism is generally related to the flexibility of environmental policies, due to the costs related to their implementation (Oates et al., 2003). However, from the point of view of technological competition, not encouraging the renewable sector can signal asset misallocation. As the consumption and production of tradable goods and services involves the efficient use of energy, trade liberalization influences total energy demand, including renewable energy. Here, two variables were used as proxies. The first and most common in the literature is trade openness. In this case we employed the indicator of international trade in goods and services on GDP, available from the World Bank. Another variable is a dummy from the years 2007 and 2008 to verify whether the international financial crisis had a positive effect on the adoption of REPs in developing countries.

The mechanism of coercion was captured by the role performed by the World Bank, similar to the idea presented by Dobbin et al. (2007).[12] This organization seems to be acting more strongly than just promoting sharing of experiences in the face of cross-compliance measures. To test the effect of coercion, we used loans to GDP ratio, information available in the World Bank's database.

Table 4 shows the descriptive statistics. There are only two cases of high correlation in absolute values: World Bank loans with income level (-0.59) and internet access with income level (0.80).

Next, we discuss the model applied to analyze all data discussed here.

[10] The Product Market Regulation (PMR) in the energy sector is an index produced by the OECD, which measures the degree of liberalization of a market structure. Information available at: https://www.oecd.org/eco/growth/indicatorsofproductmarketregulationhomepage.htm#indicators, accessed on 10th, November 2016.

[11] Available at: http://www.gwec.net/join-gwec/gwec-association-members/, accessed on November 3rd, 2016.

[12] Coercion may impact the preferences of particular actors by inducing community norms and rules, so that practical change might only appear over time. It is the case of different types of coercion, such as military force, economic sanctions, monopolization of information or knowledge (Dobbin et al., 2007). Financial incentives as a form of coercion may involve a shift of incentives, such as when the World Bank conditions a financial loan to fiscal austerity measures or certain policy implementation. Within the context of developing countries, the influence of former colonizers may be particularly relevant, given the existence of political and economic ties that have remained after independence (Stadelmann and Castro, 2014).

Table 4
Descriptive statistics of the variables of interest.

Factor		Variable label		Mean	Std. Dev.	Min	Max	Observations		Factor	Variable label		Mean	Std. Dev.	Min	Max	Observations
Domestic factors	Political economic factors	Democ	overall	4.4	6.0	−10.0	10.0	N = 1577.0	**International diffusion mechanisms**	Learning	Gwec_member	overall	0.3	0.4	0.0	1.0	N = 2311.0
			between		5.9	−10.0	10.0	n = 145.0				between		0.4	0.0	1.0	n = 194.0
			within		1.3	−6.5	12.3	T-bar = 10.9				within		0.0	0.3	0.3	T-bar = 11.9
		Green_party	overall	0.4	0.5	0.0	1.0	N = 2311.0			EU_member	overall	0.1	0.3	0.0	1.0	N = 2311.0
			between		0.5	0.0	1.0	n = 194.0				between		0.3	0.0	1.0	n = 194.0
			within		0.0	0.4	0.4	T-bar = 11.9				within		0.0	−0.5	1.0	T-bar = 11.9
		Carbon_emission	overall	39.0	19.1	0.0	86.6	N = 1506.0		Socialization	Kyoto	overall	0.9	0.3	0.0	1.0	N = 2311.0
			between		18.8	0.0	84.6	n = 138.0				between		0.3	0.0	1.0	n = 194.0
			within		3.9	16.9	59.0	T = 10.9				within		0.1	0.0	1.4	T-bar = 11.9
		Eng_exporter	overall	0.2	0.4	0.0	1.0	N = 2311.0			Num_Pol_Neighbor	overall	1.6	1.2	0.0	9.0	N = 1933.0
			between		0.4	0.0	1.0	n = 194.0				between		1.1	0.2	9.0	n = 194.0
			within		0.2	−0.7	1.1	T-bar = 11.9			Internet	overall	32.0	28.0	0.0	98.2	N = 2225.0
	Energy security	Fossil_lobby	overall	63.9	31.3	0.0	100.0	N = 1610.0				between		25.5	0.5	92.7	n = 191.0
			between		35.6	0.0	100.0	n = 163.0				within		11.5	−8.7	71.4	T-bar = 11.6
			within		2.9	49.8	78.2	T-bar = 9.9		Competition	Trade_open	overall	95.5	63.1	0.2	860.8	N = 2164.0
	Interest groups	Electric_mkt_structure	overall	2.7	1.2	0.9	6.0	N = 362.0				between		58.5	12.7	433.7	n = 187.0
			between		1.3	1.0	6.0	n = 45.0				within		22.3	256.3	522.6	T-bar = 11.6
			Within		0.4	1.8	4.9	T = 8.0		Coert	Wbloan_gdp	overall	4.2	7.9	0.0	86.6	N = 2311.0
												between		6.0	0.0	31.3	n = 194.0
												within		5.2	−22.3	59.5	T-bar = 11.9

3.3. *The Poisson regression model (PRM)*

Our dependent variable is the number of policies adopted in each country over time. This is a count variable – in such cases, models of count data, such as the Poisson regression models (PRM), are better suited for the analysis (Cameron and Triverdi, 1998). Let y_{it} be the number of renewable policies adopted by country i in time t and X a matrix that collects the independent variables, described above, that determine the number of policies adopted. Thus, the process for the number of policies adopted by each country can be described by a Poisson distribution

$$f(y_i|X) = \frac{e^{-\mu_i}\mu_i^{y_i}}{y_i!} \tag{1}$$

where $\mu_i = \exp(\boldsymbol{\beta}\mathbf{X})$ is the average number of adopted policies and $\boldsymbol{\beta}$ represents a vector of parameters of interest in the regressions.

Given the panel structure of our data, we estimate panel data Poisson regression models. The advantage is that we can control for unobserved heterogeneity among countries. A log-linear version of our regression model can be described as:

$$ln\ (\mu_{it}) = \alpha_i + \boldsymbol{\beta}\mathbf{X}_{it} + \gamma_t + u_{it} \tag{2}$$

where μ_{it} is the number of renewable energy incentive policies of a country i in year t, α_{ni} corresponds to the individual effect of country i that captures all unobserved factors, X_{nit} is a matrix that collects all independent variables (including all domestic factors and diffusion mechanisms) in country i in year t, γ_t denotes a time trend, that captures time effects common to all countries, and u_{it} is the error term.

In practice, the PRM rarely fits well due to overdispersion (when the assumption of equality of mean and variance does not hold). In these cases, estimates of PRM are consistent, but inefficient and standard errors are underestimated, resulting in spurious values in the case of large samples (Cameron and Triverdi, 2009). One way to deal with this limitation is to estimate the matrix of variance-covariance of the coefficients using the Huber/White/Sandwich (HWS) estimator. Therefore, when the equidispersion assumption is violated, we use the HWS estimator to obtain the matrix of variance-covariance of the coefficients (Wooldridge, 2010).

To account for units' heterogeneity, we estimate two variations of the panel data PRM: fixed effects (FE) and random effects (RE). The fixed effects model considers that the specific intercept of each unit (country) can be correlated with one or more covariates. As for the RE model, it is assumed that the intercept of a single unit is not correlated with the explanatory variables, as it is randomly assigned (Wooldridge, 2010).

The FE model is generally a better option for panel data, since each intercept is treated as a fixed parameter for each unit (country, in this case). The reasoning is valid when the intercept is correlated with the explanatory variables at any time. When employing RE, the constant part is not fixed, but a random variable. This type of model is most suitable when the number of subjects is large, unlike studies in small groups where the fixed effects model is widely used.

Among the advantages of panel models, we highlight that working with a larger number of observations results in more degrees of freedom of the estimates and greater efficiency and stability of the estimators. In addition, we include a time trend to control for events that affect all units in the same direction over time. To assess our hypotheses, we estimate several variants of the PRM.[13] In all specifications, we use the method of Huber/White/Sandwich (robust standard errors), since we noted overdispersion. We also tested negative binomial models, but the results were virtually the same.

[13] All statistical analyses were conducted using Stata statistical software v. 12. To test for multicollinearity, we used the variance inflation factor (VIF). Higher VIF levels indicate the presence of multicollinearity (Hair et al., 1998).

Variables that remained unchanged over time and reflected some idiosyncratic characteristics of each country, such as Greenpeace representation, were automatically excluded from the FE models. We used the Hausman test[14] to verify which model presented more efficient estimators.

4. Results and discussion: how do REPs diffuse internationally?

The estimated coefficients show how much and in what direction each independent variable (Xs) impacts our dependent variable (the number of REP adopted in each country). Positive coefficients show positive effects and vice versa. Table 5 shows the results encompassing four different samples: a global one (estimates 1–2), high-income (developed) countries (estimates 3–4), middle-income (developing) countries (estimates 5–6) and low-income countries (7–8). Countries were classified according to the World Bank's criteria, presented in Section 3.

As the Hausman test was significant, when analyzing the global sample we prefer the estimates from the fixed effects model. Nevertheless, we left both estimations in Table 5. There was a positive effect on the adoption of REPs from higher carbon emissions (economic socio-political factor), Kyoto Protocol ratification and percentage of Internet users (socialization), which reinforced the argument of diffusion. Unlike the related literature, being an energy exporter (energy security) had a positive effect on the adoption of REPs, while trade liberalization (competition) had a slight negative effect. The GWEC variable (learning) showed a positive and significant effect in two estimated models, not shown in Table 5. In addition to these, the variable that captured the time trend was significant in all models, which can signal the existence of unobserved factors that influenced countries' REP adoption. For the sample of high-income countries, we estimate several models including each hypothesis at a time (only two are shown at Table 5 – estimations 3 and 4).[15] The Hausman test was significant and therefore the FE model presented the most efficient estimators. Some of the coefficients are not statistically significant, which might be due to the presence of multicollinearity.[16] This seems to be the case with the democracy coefficient.

The variable with the greatest influence in all of the estimated models was the liberalization of the electricity market (market structure). Its negative effect on the number of policies was due to the way it was measured (less liberalized markets had a higher score). Therefore, as countries open up to international markets, we would expect higher adoption of renewable energy policies. The variable carbon emissions also had a positive effect on REP adoption. As with other samples, trade opening (competition) showed a slight and significant negative effect on the adoption of REPs. The variable democracy had a slight positive effect on two estimates, which reinforces the strength of domestic variables for this sample. Time trend showed a small effect, but significant in the estimations. The other variables that sought to capture the effect of diffusion were not significant in the FE model. In RE models, the presence of a green party (domestic factor) showed a positive and significant effect. Similarly, EU membership (learning) and the peer effect of neighboring countries' adoption (socialization) also showed a positive and significant effect. These variables do not appear in the FE model, as they are invariable for the same observation (in this case each country). The fact that a country is an energy exporter also had a positive and significant result in some estimates, similarly to what happened in the global sample.

To summarize, there is a prevalence of domestic factors in REP adoption in high-income countries. This may indicate that developed countries, although more inserted in international dynamics through channels of international trade or international institutions, are less sensitive (or vulnerable) to pressures from the external sector, so that the adoption of REPs in these countries is less influenced by international actors.

The results concerning the developing countries sample (estimates 5 and 6) show that the RE models had more efficient estimators, according to the Hausman test. The variables that had a significant and positive effect on the adoption of REPs in the RE model were: democracy, carbon emissions (economic socio-political factors) and being a GWEC member (learning). Being an exporter of energy (energy security) had a significant and negative effect on the adoption of REPs, as expected. The peer effect of neighbors and internet (socialization), as well as trade liberalization (competition) and the World Bank loans (coercion) had a slight, and significant, negative impact on the adoption of REPs. Time trend was significant in all estimations. It is valid to point out that, although not efficient, the FE estimates for the sample of developing countries showed significant and important effects of being a EU member[17] (learning) and of Kyoto Protocol ratification (socialization). In short, some variables that sought to capture the global cyclical effects, as well as the diffusion mechanisms, presented positive and significant results. However, although the variable 2008 crisis (competition) had a positive effect, it was not significant in any estimation.

The model was also applied to a sample of low-income countries. The variables of being a member of GWEC or EU were excluded, since no country in this sample fits those criteria. The Hausman test indicated that RE estimations were more efficient. We found a significant and negative effect of the fossil fuel lobby (domestic factor), which represents the percentage of domestic energy provided by fossil fuels. This confirms the strength of the brown lobby in those countries. The internet variable (socialization) showed a significant and positive effect on the adoption of REPs. Contrary to expectations, neighbors having adopted REPs in the previous year had a negative effect, which may suggest that the diffusion process for low-income countries is not explained by geographical factors; this was also the case for developing countries.

From this empirical exercise of analyzing countries by income cohorts, we could emphasize the policy diffusion argument through the importance of some international mechanisms on REP adoption by developing countries, as well as manifest the performance of relevant external, intermediate and internal actors on environmental policy adoption.

5. Conclusion and policy implications

The aim of this study was to analyze and identify the vectors and actors of the domestic and international spheres that influence countries' decision to adopt REPs, and whether this differs between developed and developing countries. Our main question, "How do REPs diffuse internationally?", can be tackled based on the other questions proposed.

Do international diffusion mechanisms influence REP adoption among countries? To answer this question, we first identified the four main mechanisms by which policies may diffuse internationally:

[14] We use the Hausman test to check the correlation between the idiosyncratic heterogeneity and the regressors. The test can help choose between FE or RE models. The null hypothesis is that the preferred model is that of random effects; the alternate hypothesis is that the model is that of fixed effects. Essentially, the test checks the existence of correlation between the unique errors and the regressors in the model. The null hypothesis is that there is no correlation between the two. Therefore, when the Hausman test is significant, it suggests that FE model features more efficient estimators.

[15] There was not any case of a high-income country that borrowed from the World Bank. Therefore, coercion could not be tested for this group.

[16] The Variance Inflation Factor (VIF) for this variable was higher than 10, a typical threshold in the literature. However, this threshold is sensitive to the sample size (or degrees of freedom to be more accurate), and given the short span of our data, we need to be cautious in interpreting VIF results.

[17] This refers to Bulgaria and Romenia being classified as developing countries in specific years of the sample.

Table 5
Results. Effect on the number of renewable energy policies.

	Global		High-income		Middle-income		Low-income	
	RE 1	FE 2	RE 3	FE 4	RE 5	FE 6	RE 7	FE 8
Democ	0.04 (0.02)	− 0.01 (0.02)			0.01 (0.03)	− 0.02 (0.02)	0.08 (0.08)	− 0.13 (0.18)
Green_party	0.10 (0.21)		0.66 (0.49)		0.16 (0.27)		0.69 (0.58)	
Carbon_emi	0.009 (0.006)	0.02* (0.009)	0.004 (0.006)	0.01* (0.008)	0.02* (0.01)	0.02 (0.02)	− 0.03* (0.015)	0.04* (0.02)
Eng_exporter	− 0.12 (0.18)	0.3*** (0.10)	0.061 (0.29)	0.096* (0.06)	− 0.078 (0.237)	0.217* (0.13)	− 0.66 (0.70)	20.71*** (− 1.33)
Fossil_lobby	0.003 (0.005)	0.015 (0.013)	0.008 (0.005)	− 0.007 (0.007)	− 0.003 (0.009)	0.002 (0.027)	− 0.04** (0.02)	− 0.14** (0.06)
Electric_mkt_structure			− 0.02 (0.1)	− 0.24** (0.12)				
GWEC_mem	0.33 (0.24)		− 0.03 (0.25)		0.52 (0.34)			
EU_member	0.25 (0.22)	0.25 (0.65)	0.315 (0.25)		0.48 (0.66)	13.97*** (− 1.04)		
Kyoto	0.18 (0.32)	0.403*** (0.14)	− 0.0734 (0.47)	0.164 (0.11)	0.03 (7.59)	14.22*** (1.02)	− 2.12*** (0.61)	
Greenpeace_member	− 0.02 (0.19)							
Num_Pol_Neighbor	0.042 (0.09)	0.08 (0.099)	0.11 (0.15)	− 0.19* (0.12)	− 0.07 (0.15)	0.05 (0.16)	− 0.78* (0.39)	− 0.878** (0.4)
Internet	0.013*** (0.005)	0.017** (0.007)	0.004 (0.004)	0.001 (0.007)	0.007 (0.01)	0.009 (0.01)	0.2*** (0.07)	0.2** (0.09)
Trade_open	− 0.006*** (0.002)	− 0.01*** (0.003)	− 0.002 (0.001)	− 0.005** (0.003)	− 0.003 (0.004)	− 0.0004 (0.006)	− 0.02 (0.01)	0.03 (0.03)
Crisis_2008					0.208 (0.189)	0.271 (0.166)	15.71 (1.57)	16.06*** (1.05)
Wbloan_gdp	− 0.035 (0.039)	− 0.042 (0.06)				0.0410 (0.0881)		
Time Trend	0.06** (0.03)	0.06** (0.03)	0.02 (0.04)	0.07** (0.04)	0.15*** (0.05)	0.11* (0.06)	0.39 (0.12)	0.32* (0.16)
_cons	− 0.79 (0.56)		− 0.40 (1.17)		− 1.55 (7.75)		− 15.91 (1.59)	
Lnalpha _cons	− 0.18 (0.22)		− 3.13 (6.3)		0.08 (0.31)			
N	1020	886	232	240	565	464	91	76
Hausman Test		103,34***		38,22***		4,27		0,03
VIF	6,81	7,23	13,54	12,06	8,62	9,28	9,28	7,93

Standard Errors in parentheses.
* p < 0.10.
** p < 0.05.
*** p < 0.01.

learning, socialization, competition and coercion. Next, we assessed the literature and reported the main actors and factors behind the process. In order to test the theory from an empirical perspective, we submitted the policy diffusion process to quantitative analysis by employing a Poisson regression model for panel data, involving 194 countries in a time frame of 10 years. From a global point of view, we cannot reject the hypothesis of international policy diffusion. Table 6 summarizes the results, considering only the statistical significant effects from the best fits.

In short, international socialization – as well as learning – showed positive effects on REP adoption. However, domestic factors also played an important role. This is linked to another of our questions, "What predominates when considering REP diffusion, national or international factors?" Specifically, the level of carbon emissions, as well as concerns on energy security, are the two main drivers that predominated on the adoption of REPs.

Regarding the question "Which actors are diffusing these REPs?", we tried to boost the analysis by identifying the main actors involved in the diffusion of policies related to the wind sector. It was possible to perceive that the formulators of national policies are susceptible to the influence of multiple groups of actors, such as other countries, companies, intergovernmental organizations, public-private networks, civil society movements, and private interest groups.

Regarding the question "Are there differences between developed and developing countries?", when considering solely the sample of developed countries domestic factors may appear as determinant on REP adoption. International diffusion mechanisms also seem important. Either by learning, through EU membership or by socialization, the peer

Table 6
Summary of the results in a comparative perspective.

	Factor	Variable	Global	High-income	Middle-income	Low-income
Domestic factors	Political economic factors	Democ				
		Green_party				
		Carbon_emi	+	+	+	−
		Energy security	Eng_exporter	+	+	
	Interest groups	Fossil_lobby				−
		Electric_mkt_structure		−		
International diffusion mechanisms	Learning	GWEC_mem				
		EU_member			+	
	Socialization	Kyoto	+		+	−
		Greenpeace_member				
		Num_Pol_Neighbor			−	−
		Internet	+		+	+
	Competition	Trade_open	−	−		
		crisis_2008				+
	Coertion	wbloan_gdp				
		Time Trend	+	+	+	+

* The sign shows a statistic significant influence of the variable on the number of renewable energy policies adopted, considering only the best fits according to the Hausman tests employed.

effect of neighboring countries adopting REPs was observed in this group. In the case of developing countries, being more democratic or having an electricity sector that emits more carbon was positively related to the adoption of REPs.

Still answering this question, our results showed that income matters when the issue is adoption of REPs, and the analysis in cohorts brought significant findings on how different factors and actors may influence policy adoption.

Overall, we show some of the key actors related to REPs and we note that the causal mechanisms that lead to the adoption of REPs may differ among countries according to their level of economic development. Our results show that, in the case of high-income countries, the effect of liberalizing the electricity market may have a positive effect on the adoption of REPs, especially due to the performance of pressure groups. In the sample of developing countries, domestic elements related to energy security appeared to have greater relevance to REP adoption, but diffusion through socialization also played an important role. Those facts reinforce the idea that, while policy adoption by developed countries may be related to domestic drivers, developing countries are more susceptible to international pressures and socialization from interest groups and international organizations. Even more interestingly, some of our results corroborate Stadelmann and Castro's (2014) findings, despite the different database and econometric techniques used.

Nevertheless, we acknowledge the limitations of this study, especially regarding the analysis on the actors of policy diffusion and of other relevant vectors of this process. We also find it interesting to deepen the understanding on how this process may develop regarding other energy sources, in addition to the case of the wind sector presented here. Two main strategies to improve this research agenda are: first methodological refinements regarding the qualitative analysis on the actors behind policy diffusion, and second, to expand the analysis to other kinds of energy sources in order to seek similar patterns on the renewable energy policy diffusion process.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.enpol.2018.10.064.

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